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to Landscape Configuration
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"Gene Flow and Barriers to Dispersal in
Boreal Owls"

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Boreal Owl Population Trend, Habitat Use, And Dispersal in 1998: Final Report

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Table Of Contents

WHAT THIS REPORT COVERS 3

BACKGROUND 3

Chapter 1

 METAPOPULATION STRUCTURE AND DISPERSAL..... 4

 Goal of Research 4

 Rationale..... 5

 Metapopulation Theory 6

 Methods 6

 Collection of Blood and Tissue Samples 7

 Genetic Analysis..... 7

 Matrix/Gene Flow Model 8

 Results From 1998 Field Studies..... 9

 Idaho Panhandle National Forest..... 9

 Payette National Forest, Idaho..... 9

 Beaverhead National Forest, Montana..... 10

 Medicine-Bow National Forest, Wyoming..... 10

 Establishment Of New Nest Boxes..... 12

Chapter 2

 LONG-TERM MONITORING OF A NEST BOX SYSTEM ON THE PAYETTE
 NATIONAL FOREST..... 12

 Introduction 12

 Methods 13

 Nest Box Placement..... 13

 Nest Box Design And Construction..... 14

 Monitoring Nest Boxes..... 14

 Monitoring Results 15

 Discussion..... 16

LITERATURE CITED..... 18

WHAT THIS REPORT COVERS

After joining the University of Wyoming in 1995 I began building a research program examining the consequences of forest management on certain vertebrates in subalpine forests of the Rockies. This research is not a change in direction but an extension of the program I maintained while working for various employers during the previous decade. I now have 5 graduate students and a research associate in my lab working on projects related to my broad research goals. Our projects address a variety of spatial and temporal scales and several areas of population ecology. For instance, Ph.D. students in the lab are addressing questions that range from feeding ecology and gut physiology of northern flying squirrels to metapopulation structure of boreal owls.

This year, funding from several sources (Rocky Mountain Forest and Range Experiment Station, Idaho Fish and Game, several national forests, the F. L. Clarke Memorial Fund, University of Wyoming) supported field studies of boreal owls. Although individual grants supported fieldwork directed at particular questions, the research and management studies on boreal owls are all related. Therefore, I chose to write a single final report integrating the work from a couple several projects. Because none of these projects is near completion, this report is a summary and designed to describe the field work and analysis accomplished with the funding we received. More extensive analysis and products will be produced during the coming year.

BACKGROUND

My work on boreal owls currently addresses 4 major topics: 1) administrative studies monitoring population trend, 2) patterns of habitat use at a landscape scale, 3) comparative demography of boreal owls in different environments, and 4) metapopulation structure and movements of boreal owls in North America. All of these studies build upon my earliest studies of boreal owls in the wilderness of central Idaho (e.g. Hayward et al 1993) and rely on the cooperative nest-box monitoring program I established with numerous cooperators in the Rockies and Alaska.

From 1987-1989 I established systems of nest boxes on three national forests in the Northern Rocky Mountains (Payette, Idaho Panhandle, and Beaverhead National Forests). These systems have been maintained to varying degrees. We have monitored the boxes on the Payette N.F. (max. of 455 boxes) yearly since 1988. Boxes on the Idaho Panhandle have been monitored sporadically and have not been maintained during the past 5 years. Boxes on the Beaverhead N. F. were monitored for about 5 consecutive years but have not been monitored continuously during the last half of the decade.

Currently we work with 5 other National Forests and the Colorado State Forest Service on associated nest box monitoring systems.

This report will be organized with 2 chapters. The first will describe fieldwork and cooperative efforts associated with our studies of boreal owl metapopulation structure. The second will review results from our long-term monitoring program on the Payette National Forest, Idaho. In the second chapter I provide a review of our analysis of landscape scale habitat use.

Chapter 1 METAPOPOPULATION STRUCTURE AND DISPERSAL

PATTERNS IN BOREAL OWLS

Goal of Research

In this work we use molecular techniques to assess dispersal of boreal owls (*Aegolius funereus*) and identify the metapopulation structure of the species in North America. We will evaluate gene flow between disjunct populations of boreal owls in the Rocky Mountains and Cascade range and more contiguous populations of Alaska and Canada. Boreal owls occur throughout Alaska's and Canada's boreal forests as a largely continuous population. In the western United States, however, boreal owl populations occur in disjunct subpopulations in sub-alpine forests. Because boreal owls in the western U. S. are found only in high elevation coniferous forest, their distribution suggests a natural metapopulation structure (Hayward et al. 1993). We have hypothesized that small sub-populations are separated by large areas of unsuitable habitat, with dispersal acting to connect these subpopulations.

Within the context of metapopulation structure, boreal owls exhibit a spectrum of connectivity. The highly linked populations of northern Canada constitute a mainland population, but we predict that the Rocky Mountain populations are so distant from this mainland that genetic differentiation has occurred. However, subpopulations of southwestern Canada probably interact with the larger continuous northern populations in an island-mainland relationship. By analyzing DNA samples we can assess and compare dispersal and gene flow among populations which differ in geographic isolation (Bruford and Wayne 1993) and examine the results in light of metapopulation theory.

Our main objective is to investigate levels of dispersal between subpopulations of boreal owls in a variety of geographic configurations in North America. We expect to find that some populations are more isolated than others, with lower rates of gene flow. We can determine which features may act as barriers to dispersal by comparing habitat types surrounding

populations with high and low rates of gene flow, thus integrating both landscape ecology and metapopulation theory. This information can then be applied to resource management, thus providing necessary data for the design of forest harvest strategies that decrease the likelihood of extinction of subpopulations by retaining habitat configurations necessary for dispersal.

This study includes three main objectives: (1) to test the hypothesis that boreal owls exhibit a mainland population structure in northern boreal forests but a well structured metapopulation in the western United States by comparing rates of gene flow; (2) to build a model of boreal owl population structure suitable to identify barriers to dispersal and critical subpopulations; and (3) to test whether boreal owls can be used as a model metapopulation for higher vertebrates.

Rationale

Timber harvest in the western U.S. has recently expanded to include more subalpine spruce-fir in order to reduce pressure on lower elevation pine stands. Therefore, species associated with spruce-fir are experiencing increasing levels of habitat alteration. Current trends in species management emphasize waiting until persistence of a species is in peril prior to proposing sound management strategy. This emergency room approach to conservation leads to high cost and low success. Especially for obligates of mature forests, restoration of habitat and enhancement of population processes can take many generations, thus reducing the likelihood of success if these processes have been seriously degraded.

Because boreal owls are classified as a sensitive species in most western National Forests, a management plan for this species is necessary. However, the state of understanding of boreal owl ecology in North America is very poor (Hayward 1997). Only 4 major studies have been conducted and of these, none extended more than 4 years (Bondrup-Nielsen 1978, Palmer 1986, Hayward et al. 1992, Hayward et al. 1993). A management plan based on insufficient ecological data will not be sound or reliable.

Investigation of dispersal rates and barriers to dispersal is an important step to understanding the response of boreal owls to forest management. Recent research on metapopulation dynamics highlights the interdependency of seemingly independent subpopulations, and the negative consequences of isolating such subpopulations. Our research will not only contribute essential information to the development of a conservation strategy for boreal owls in North America; it will also provide critical empirical data to the general development of metapopulation theory.

Our sampling design encompasses the entire distribution of boreal owls in North America. Genetic analysis is the ideal technique for investigating exchange of individuals at this scale. Prior to genetic analysis, radio telemetry was employed to investigate dispersal. This accounts for the paucity of reliable data on dispersal rates and disperser success. The long-distance disperser is an exception in a normal population. If one individual in 100 emigrates, a population of 100 radioed individuals will provide only one data point, assuming that the disperser was successful and survived to reproduce in a new population. Modern genetic techniques employ allele frequencies to calculate gene flow among populations. With sufficient sample sizes for each population, and sufficient allele diversity among populations, origins of individuals who have dispersed can be identified. Even with very small sample sizes, differences among populations in genetic diversity and genetic make-up are apparent. Microsatellite DNA analysis allows for collection of dispersal data on a large scale. Such large scale data will help provide forest managers and biologists with necessary information for management for long-term persistence of this species, thus avoiding future conflicts like those over the northern spotted owl.

Metapopulation Theory

In addition to providing knowledge necessary for management of boreal owls, our study will provide insight to metapopulation theory. Understanding of metapopulation dynamics suffers from a lack of empirical evidence regarding the structure and function of medium and large vertebrate populations that occur as natural metapopulations (Stacey et al. 1997). As populations of many species become fragmented due to human influences, interest in the problems associated with fragmentation has escalated. However, most studies involve species whose habitat has become disjunct rather than a naturally occurring metapopulation. These species may not have highly developed dispersal mechanisms. Boreal owls in the western U.S. have persisted in a highly fragmented system over numerous generations. Dispersal is vital to their ability to persist in such a system, and therefore this mechanism is well developed and highly effective. The natural distribution of boreal owls in North America provides an opportunity to study dispersal dynamics and genetic diversity of a species that likely exhibits a variety of population structures: high connectivity in the north, island-mainland structure in southern Canada, and classic metapopulation in the western U.S. We predict that this species will also exhibit a range of genetic diversity reflecting the importance of long-distance dispersal to local population dynamics.

Methods

We are studying movements and metapopulation structure of boreal owls in North America by examining the genetic patterns throughout the species range. In contrast with much of the work on metapopulations, our approach will have a strong empirical base and focus on a wide ranging vertebrate that exhibits a dissected distribution on a continental scale.

Collection of Blood and Tissue Samples

Beginning in the summer of 1998 we collected tissue samples from boreal owls from individuals throughout their North American range. Collection of blood samples for DNA analysis has been facilitated by the research program established in cooperation with a network of collaborators, including the U.S. Forest Service in Washington, Oregon, Idaho, Montana, Utah, Wyoming, Colorado, Alaska, Alberta, and Saskatchewan. Biologists in Alaska, Colorado, and Wyoming have agreed to collect blood samples and send them to our lab. However, nest boxes throughout much of the Rockies were checked by us or trained assistants. Tissue or feathers from failed nests or from museum specimens will also provide valuable microsatellite DNA samples. Over 200 tissue samples are identified for shipped to us from Minnesota and Saskatchewan. These samples consist of boreal owls collected during a winter die-off in 1996. The especially harsh winter caused boreal owls to migrate from central Canada to southcentral Canada and northcentral U.S., where they were collected after they died. While their location of origin is unknown, these samples will provide valuable insight into the genetic diversity of boreal owls from the boreal forests of central Canada.

Field work in the Rockies began in 1998 and will continue each spring and summer through 2000. During nesting, which lasts May - July, we will collect blood and tissue samples from adults and nestlings throughout the U.S. and Canada for genetic analysis. Nestlings and adults are banded with Fish and Wildlife identification bands and a blood sample is collected. Boreal owl nestlings as young as 1 day old have been bled successfully with no apparent detrimental effects.

Genetic Analysis

Blood samples stored in lysis buffer are being processed in the microsatellite DNA laboratory of D. McDonald at the University of Wyoming. Recently, nuclear loci have been identified that are highly polymorphic and potentially allow the identification of population-specific

polymorphisms (Bruford and Wayne 1993, Queller et al. 1993). These loci, termed microsatellites, are simple, tandemly repeated sequences of DNA (Beckmann and Weber 1992) that evolve through the gain or loss of repeat units. Mutation rates may be as high as 1×10^{-3} per generation, and drift is proportional to the product of population size and mutation rate (Garcia-Moreno et al. 1996). Thus, microsatellites may reveal differentiation among small, isolated populations that cannot be distinguished by analysis of other, more slowly evolving loci (Bruford and Wayne 1993).

Microsatellite genotypes will be developed using methods outlined in McDonald and Potts (1994; 1997) with minor modifications suggested by Licor, Inc., the manufacturer of the automated DNA sequencer. DNA will be extracted and amplified by polymerase chain reaction (PCR) using an MJR PTC-200 Peltier thermocycler. The microsatellite laboratory at University of Wyoming has a battery of avian primers available, and other primers that amplify DNA from many species of Strigiformes have been identified in a previous study (B. Johnson, unpubl. data).

Matrix/Gene Flow Model

We will enter rates of genetic exchange in a geographic information system (GIS) in order to evaluate the effects of different surrounding matrix types and distances on dispersal. GIS base maps will be drawn largely from GAP analysis data completed for all western states north of New Mexico. The GAP data will facilitate modeling metapopulation structure of boreal owls in the region. GAP data provides information on the extent of subalpine habitat, which, for our model, we will assume to be the range of boreal owls. Data on dispersal will be integrated into the metapopulation model to examine connectivity. We will test the robustness of the model by making predictions about sampled populations and comparing predicted rates of gene flow with measured rates of gene flow.

The integration of a metapopulation model and a model of movements will allow us to form inferences regarding the influence of management in the matrix on metapopulation dynamics. If geographic distance between populations is relatively short yet genetic distance is great, we will look at the intermediate geographic features in order to identify the cause of low dispersal rates. We expect that certain habitat types, such as lower elevation forested stands or partial cuts, will facilitate dispersal while other types, such as prairie, extensive clear cuts, or large bodies of water will prove to be barriers. For example, populations in southern Wyoming and western Colorado are separated from populations to the north by an extensive basin east of the continental divide. These treeless plains may act to isolate the very southern range of boreal

owls from the rest of the metapopulation. If this is the case, we expect to see different allele frequencies in these southern populations and possibly reduced heterozygosity. By modeling habitat-dispersal associations we can apply our results to the entire metapopulation of boreal owls and produce a predictive map of gene flow throughout their range in North America. Furthermore, our model will help identify critical subpopulations that link portions of the metapopulation or provide a source for dispersers to multiple subpopulations. Such valuable information will be released to scientists and forest managers through publication in the refereed literature and development of technology transfer documents.

Results From 1998 Field Studies

In addition to samples obtained from our monitoring efforts, we obtained (or have agreements to obtain) tissue samples from cooperators in Canada, Alaska, and Colorado. This included samples from 16 boreal owls near McGrath, Alaska; +200 boreal owls in Canada, and 6 boreal owls from the SanJuan mountains of southern Colorado.

We monitored nest boxes on 4 National Forests during the summer of 1998. Nest boxes on an additional forest, the Okanogan National Forest in Washington, were inaccessible due to an especially late snow storm, but we plan to monitor them in future years. Results from each of the forests is summarized below.

Idaho Panhandle National Forest

Bonner's Ferry.--Ninety-five of 300 nest boxes on the Bonner's Ferry District of Idaho Panhandle National Forest were checked and most appeared to be unoccupied. Of the 95 we checked (or attempted to check), only 43 were accessible and in a usable state. There were 27 occurrences of lichen in the boxes, 5 with grass, and 5 with other contents (pine needles, old scat, etc.). No fresh or old owl bricks, owl nests, or squirrel nests were observed.

Priest Lake.--Fifty nest boxes on the Priest Lake District of Idaho Panhandle National Forest were checked and most appeared to be unoccupied. Of the 50 we checked 37 were in a usable state. There were 4 occurrences of lichen in the boxes, 1 with grass, 1 saw-whet owl nest, and 1 flying squirrel nest.

Payette National Forest, Idaho

River of No Return Wilderness.--We checked 48 nest boxes hung in Chamberlain Basin in 1984 and examined over 100 natural cavities for owl used. Monitoring began on 28 May and ended 4 June. Of 48 nest boxes, 5 were not in usable condition. Current use by wildlife included 3 saw-whet owl nests, 0 boreal owl nests, and 1 flying squirrel nest. Blood samples were obtained from 2 adult saw-whet females and 5 nestlings. The status of the saw-whet nests included: 1 nest with 5 eggs, 1 nest with 6 eggs, and 1 nest with 5 young.

We located one saw-whet owl nest, one pygmy owl nest, and one boreal owl nest in natural cavities. The boreal owl nest occupied a cavity about 20 m high in a leaning, rotten ponderosa pine snag on the first ridge immediately west of Chamberlain Guard Station (Flossie

Hill) within 200 meters of a boreal owl nest site from 1984 and 300 m from a boreal owl nest from 1985. The condition of the nest tree prevented us from capturing the owls to obtain blood samples.

Long-term Monitoring System.--Details of the results from nest-box monitoring on the managed portion of the Payette National Forest are presented in a later section of this report (see Nest Box Monitoring: Payette National Forest). We obtained blood from 37 boreal owls captured from 7 nests in the nest-box system on the Payette N. F. (Tables 1 and 2).

Beaverhead National Forest, Montana

There are 194 nest boxes on the Beaverhead National Forest. These boxes were established in 1989 by Patricia Heekin working for G. Hayward and J. Jones. They were monitored for the first few years after being established but, due to funding constraints and changes in Forest personnel, have not been maintained or monitored on a regular basis for the past few years. We checked all 194 boxes between 18 May and 6 July, 1998 and captured 28 individuals from 10 nests (Tables 1 and 2).

Boreal owls in Idaho and Montana appeared to be nesting earlier than usual and over a longer period of time. Earliest estimated laying date in Montana was 1 April and the latest was 10 June. Four nests on the Beaverhead N.F. had projected fledging dates in July, and all four were predated and/or abandoned. In contrast, all earlier nests on the Beaverhead N.F. appeared to successfully fledge young.

The first documented second clutch for a boreal owl (after raising a brood) was recorded on the Beaverhead N. F. A banded female that fledged 6 chicks in May was found incubating 5 eggs in a nearby box at the end of June. When we returned in July, the nest had been abandoned and/or predated.

Medicine-Bow National Forest, Wyoming

One-hundred and fifty boxes were monitored on the Medicine Bow National Forest. Two active boreal owl nests were located; one in a natural cavity. Capture data is presented below (Table 2). Data on nest box use and condition are available through the Laramie office of the U.S.F.S.

Table 1. Nest box use on Payette National Forest, Idaho and Beaverhead National Forest, Montana. Boxes were monitored during May-June 1998.

Contents	Payette National Forest		Beaverhead National Forest	
	Number	Percent	Number	Percent
Lichen	44	12	32	18
Grass	39	11	98	55
Boreal Owl nest	7	2	10	6
Saw Whet Owl nest	9	2	1	1
Flying Squirrel	4	1	1	1
Pine Squirrel	5	1	6	3
Fresh owl brick	9	2	7	4
Old owl brick	2	1	4	2
Other	28	8	9	5
Boxes available	369		177	

Table 2. Owl captures in Montana, Idaho, and Wyoming, May-June 1998.

Forest/Species	No. Nests	Avg. min. clutch size	No. individs. captured	No. banded	Adult male- s	Adult fe- males	Juvenile
Beaverhead N.F.							
Boreal Owl	10	3.78	28	27	1	8	19
Saw Whet Owl	1	6.00	1	0	0	1	0
Payette N.F.							
Boreal Owl	7	4.29	37	37	4	4	29
Saw Whet Owl	9	4.25	19	18	0	5	15
Med. Bow N.F.							
Boreal Owl	2	2.00	5	5	1	0	4

Saw Whet	0	-	0	0	0	0	0
Owl							

Establishment Of New Nest Boxes

We established three new systems of nest boxes this summer. These systems will be monitored in future years in order to obtain blood samples from boreal owls in these areas and to provide the associated forests further information on their boreal owl populations. Additionally, the new system established on the Hahn’s Peak district, Routt National Forest, will provide valuable information on the effects of the 1997 blowdown on cavity nesting species.

- Bridger-Teton National Forest (Grey’s River District) - 100 boxes
- Routt National Forest (Parks District) - 70 boxes
- Routt National Forest (Hahn’s Peak district) - 250 boxes

Support for the establishment of these systems was provided by the individual districts (vehicles, housing, logistics) and by the U.S.F.S. Rocky Mountain Research Station.

Chapter 2 LONG-TERM MONITORING OF A NEST BOX SYSTEM ON THE PAYETTE NATIONAL FOREST

Introduction

A system of nest-boxes on the McCall and New Meadows Districts was established in 1987 to examine the efficacy of employing nest-boxes as a tool to monitor owl foraging habitat quality on managed forest lands. The system was expanded during the first 3 years of the monitoring program to a maximum of 455 boxes. Although the nest box program was established to test a monitoring approach, it has yielded additional benefits for natural resource managers and research. Furthermore, the program has joined several government and private organizations in a cooperative program to meet a diversity of goals.

In 1998, field work was supported largely by the National Geographic Society. Other agencies contributing funding or logistical support included Idaho Fish and Game, University of Wyoming, Payette National Forest, and Bureau of Land Management. Information collected during the summer of 1998 supported the following major efforts (as demonstrated from past publications from our lab, these studies contribute in lesser ways to many projects):

- 1) Long-term monitoring of boreal and saw-whet owl nest occupancy and productivity for the Payette National Forest. This is the only long-term monitoring program of its kind in North America.
- 2) Research examining the relationship between northern flying squirrels and fungi/lichen. This research has important implications for understanding flying squirrel ecology and determining the critical link between these squirrels and mycorrhizal fungi (fungi important to tree establishment and productivity).
- 3) Research funded by the University of Wyoming examining the habitat associations of boreal owls at landscape scales. This study will use 7 years of monitoring, prior to the Blackwell fires, to examine habitat features associated with boreal owl site occupancy and productivity.
- 4) As described earlier in this report, tissue samples from boreal owls on the Payette will be important in studies examining movements of boreal owls among subpopulations in North America, particularly the Rocky Mountains. Data from the Payette National Forest will play a critical role in this study.

Methods

Our long-term monitoring program has continued without interruption for 11 years. Rationale for the work and methods have been included in earlier reports. Therefore we will provide only an abbreviated explanation of methods here.

Nest Box Placement

We hung 283 boxes on the McCall and New Meadows districts of the Payette N.F. in July 1987 and an additional 172 boxes were hung by August 1989. Due to damage to individual boxes, changes in access, and removal of trees by wood-cutters or loggers the number of boxes available for wildlife use varies each year. Over the first 6 years of monitoring, landscape characteristics did not change significantly. During this period, however, spruce beetle attacks began to kill many overstory trees in portions of the monitoring area but stem density and many characteristics of forest structure did not change significantly. In 1993, after the owl nesting season, timber harvest was initiated in a portion of the study area south and west of Sesash summit. After the owl nesting season in 1994 a portion of the monitoring area experienced a major stand removal, wildfire. This disturbance changed habitat characteristics over broad landscapes. The characteristics of the 1994 fire and the timber sales begun in 1993 are documented in agency

records. Eighty nest boxes were initially destroyed or rendered unusable by the 1994 fires. Management activities associated with the fire have lead to continual loss of nest boxes from the monitoring system. We continued replacing nest boxes each year since the fire as treefall, harvest, and other disturbances make boxes unusable. We attempt to relocate nest boxes near their original site when possible. In some instances, however, safe trees for box attachment are not available and boxes have been placed along new monitoring routes or within past routes.

When we established the nest box system we spaced nest boxes at 0.5 km intervals along primary, secondary, and primitive haul roads. Wherever possible, we hung the boxes along several roads in a network so the boxes formed a grid-like pattern rather than a single string of boxes along 1 corridor. In many areas, the existing road network and road management policy lead to linear configurations; approximately 30% of the boxes were in a grid-like pattern.

Each box was hung in a tree 10 to 70 m from the road in a position making the box difficult to see from the road. We climbed live conifers using forester's climbing spurs and hung each box between 4.5-10 m high after trimming all branches below box height. In all cases the box faced a small (at least 3x3 m) forest opening providing a clear flight path to the box.

Nest Box Design And Construction

Box design followed Korpimaki (1985). Inside box dimensions were: bottom 20x20 cm; front height 46 cm, back height 51 cm, and cavity dia 9 cm. We constructed nest boxes from rough cut, 3 cm pine and fir. Constructing 300 boxes required 382 m of 3x20 cm (1x8 in) and 382 m of 3x25 cm (1x10 in) lumber. Five cm of wood chips and saw-dust were placed in the bottom of each box.

Monitoring Nest Boxes

We monitored nest boxes on the Payette N. F. for 11 years (1988-1998). We checked boxes each spring when snow conditions permitted travel. Monitoring generally began between 22 and 30 May (but as late as 8 June) and extended into early July. However, virtually all boxes were initially checked by the end of June. To determine nest box use, we climbed each tree once each spring during the nesting season using climbing spurs or examined the nest box using a nest-box checker (Hayward and Deal 1993) and recorded nest box contents. Adult female owls and owlets in the box were captured, identified, and banded, and the box was recorded as occupied. We attempted to capture male owls at occupied boxes using a box trap. Males are

captured when they bring prey to the nest at night. This method is successful at only a fraction of the nest boxes. Presence of a mat of owl feces and prey remains or pellets was considered evidence of a nesting attempt. Owl species was not recorded unless diagnostic feathers were found in the box or the species could be identified by night-time vocalizations heard in the vicinity of the box. We removed nest contents other than wood chips and sawdust and repaired damaged boxes.

Monitoring Results

Between 23 May and 14 Jun 1998, Patricia Heekin, Shelli Dubay, Tim Hampton, Doug Keinath, Kathy Keinath, Kim Simpson, and Richard Russell checked an estimated 393 usable nest boxes. Overall, we observed animals in 34 (8.6%) of the nest boxes and sign of use in at least 84 (21.4) more of the boxes. As in other years, boxes were used by northern flying squirrels (*Glaucomys sabrinus*), pine squirrels (*Tamiasciurus hudsonicus*), saw-whet owls (*A. acadicus*), northern flicker (*Colaptes auratus*), and boreal owls (*Aegolius funereus*).

Boreal owls nested in 7 (1.8%) of the nest boxes. Northern saw-whet owls nested in 9 (2.3%) of the nest boxes. Combining boxes used by boreal and saw-whet owls and those with sign that nests were at least initiated in them this year (eggs, fresh partial brick) with 1 box containing some sign of recent owl use (a brick suggesting possible predation) and one box with cached prey, 25 (6.3%) of the usable nest boxes were used by owls (Table 3). Use by owls, especially boreal owls was up substantially from the previous year and exceeds the value from 1996 when the initial decline after the fire was first observed.

The number of boxes with unidentified owls observed this summer was disturbing. Monitoring began early (among the earliest years during the 11 year time series). Early monitoring should prevent the problem of owls nesting prior to monitoring. However, nesting in Montana (Beaverhead N. F.) also appeared to have begun especially early. Based on the age of young observed in nests on the Payette N. F., nesting did appear to begin early in 1998 and the extremely early initiation dates may explain the number of unidentified owl nests located.

We captured and banded 4 adult female, 4 adult male, and 29 nestling boreal owls. A male boreal owl captured on 13 June, 1998 was first banded as a nestling on 1 June 1990 at a nest box in the same drainage about 5 km away. We captured and banded 5 adult female, 0 adult male, and 15 nestling saw-whet owls.

We observed flying squirrels in 4 (1.02%) of the boxes, a continued decline in numbers since 1990 (Table 3). Lichen or other sign of flying squirrels occurred in 45 other boxes. The number of boxes

with lichen is greater than in 1997 (31 boxes with lichen recorded) but still far less than in 1996 (86) and earlier years. This sign (lichen) is difficult to interpret by year of origin and we don't feel this metric alone should be used to interpret changes in flying squirrel abundance. However, the magnitude of the difference among years, and the coincident pattern for lichen and flying squirrel nests, suggests a potential difference in the number of flying squirrels using the nest boxes.

Pine squirrels were observed in 5 nest boxes and grass nests (which we interpret as sign of pine squirrel use) occurred in 39 boxes; a substantial increase compared to 1997. In 1997, we recorded no pine squirrels in boxes and only 12 boxes with grass nests. As with lichen, however, grass in nest boxes is difficult to interpret by year of origin.

Table 3. Nest box occupancy by boreal owls, saw-whet owls, and flying squirrels from 1988-1998 on the Payette National Forest, Idaho. Percent use given in parenthesis refers to proportional use of the boxes classified as usable that year. These results should be considered preliminary as the criteria for 'usable' boxes could be approached differently and further analysis of habitat use patterns may suggest a reasonable system for stratifying boxes. Boxes recorded as unknown owls includes boxes with cached prey, evidence of the start of a nest, or frequently, evidence of predation during nesting.

Year	Boreal	Saw-whet	Unknown owls	Flying Squirrels	Usable
1988	9 (3.3)	5 (2)	3	9 (3)	267
1989	11 (3.7)	6 (2.0)	3	18 (6)	298
1990	22 (5.3)	13 (3.1)	5	24 (5.7)	417
1991	15 (3.5)	11 (2.6)	11	22 (5.16)	426
1992	15 (3.4)	12 (2.7)	7	18 (4.1)	441
1993	13 (2.9)	11 (2.5)	8	10 (2.3)	444
1994	14 (3.2)	2 (0.45)	6	15 (3.4)	440
1995	12 (3.4)	5 (1.4)	1	13 (3.7)	355
1996	5 (1.3)	4 (1.04)	4	7 (1.8)	382
1997	1 (0.2)	7 (1.7)	2	6 (1.4)	411
1998	7 (1.78)	9 (2.29)	9	4 (1.02)	393

Discussion

Reports from the past 2 years of monitoring included complete discussions of the patterns in owl and flying squirrel occupancy observed during the past decade. Therefore, this discussion will be brief.

Boreal and saw-whet owls both showed increased rates of nest box occupancy. The pattern of occupancy for boreal owls suggests a delayed negative response (1996, 1997) to the 1994 fires (boreal owls occupied similar numbers of boxes from 1991-1995) and potentially a partial recovery initiated in 1998. The 1994 fire may have eliminated nearly 50% of the forest in the area monitored by the nest box system (Richard Russell is currently examining GIS coverage for the area). Given this loss, I predict that boreal owl nest box occupancy will remain at or below 2% in the future.

The male boreal owl recaptured at a nest box near Burgdorff represents one of the oldest records for boreal owls. Boreal owls recaptured in Europe have been reported up to 9 years old. The age of the owl recaptured on the Payette is known because it was initially captured as a nestling. This owl entered the population in the year with the highest nest box occupancy by boreal owls of the 11 years we have monitored the system.

The nest box system was established primarily to examine boreal owl population trend. Habitat use and trend in saw-whet owls has not been closely examined. I hope to begin to examine the data on saw-whet owl use in the near future. The pattern of occupancy for saw-whet owls is not easily explained by the pattern of habitat disturbance in the monitoring area. Saw-whet owls reached their lowest level of occupancy prior to the fire (in the spring prior to the fire). Occupancy in 1998 was similar to the high level of occupancy observed from 1990-1993.

Nest box use by flying squirrels, as measured by the number of nest boxes occupied by squirrels during monitoring and by the number of boxes with lichen, continued to decline. Like boreal owls, occupancy rates for flying squirrels did not decline immediately following the 1994 fire but began declining after one year. Unlike boreal owls, flying squirrel occupancy did not recover in 1998 but continued to decline. Interpreting the occupancy rates is difficult. While we find flying squirrels in nest boxes each year, we have little understanding regarding the use of 'occupancy' by flying squirrels as a measure of population characteristics. Unlike the boreal and saw-whet owls, flying squirrels do not consistently occupy a single cavity or nest box through the breeding season. Furthermore, flying squirrels who are not breeding, use boxes for roosting. Finally, because flying squirrels may quietly leave a nest box while we climb the tree to check for occupancy, some squirrels occupying nest boxes may not be detected during monitoring. We suspect, however, that bias in the measurement of occupancy can not be responsible for the perceived decline. During the period of declining occupancy rates (1996-1998) a graduate student (Shelli Dubay) whose dissertation focuses on flying squirrels, has been assisting with field work. Therefore, we would expect the probability of detecting flying squirrels would be highest during this period because of the efforts to note all flying squirrels.

I would like to close with a note regarding the future of our monitoring program. The increase in boreal owl occupancy observed in 1998 was unexpected! Therefore, the long-term consequences of the 1994 fire on boreal owls can not be predicted without additional monitoring. Furthermore, because of the importance of the Payette N.F. in our work on movements by boreal owls, we expect to continue monitoring the nest box system for the next two years. We will be seeking funding to support the monitoring program from a number of sources. Currently we have grants submitted to National Geographic

Society and the U.S. Fish and Wildlife Service. We will be seeking funding from several other government and private sources.

I expect to have two manuscripts ready for technical journals (e.g. Journal of Wildlife Management, Landscape Ecology) by this time next year. Richard Russell is scheduled to complete his Master's thesis by early next fall. This work will include an analysis of trend in boreal owls based on occupancy and productivity. The major focus of the work will be an analysis of landscape scale habitat characteristics associated with boreal owls. This work will use the long-term monitoring data on occupancy and productivity, and GIS analysis of vegetation and other habitat features. The products from this work will be written to provide managers with information to more effectively evaluate the potential effects of land management decisions.

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